



APPARATUS FOR INSPECTING A SPECIMEN

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is related to a manufacturing system for a substrate having a circuit pattern, such as a semiconductor device or liquid crystal display, and more particularly to the technology for inspecting a substrate pattern during fabrication.

2. Description of the Related Art

Conventional optical or electron beam pattern inspection systems are described in Japanese Patent Laid-open No. H5-258703 and Japanese Patent Laid-open No. H11-160247.

Fig. 1 shows the constitution disclosed in Japanese Patent Laid-open No. H5-258703 as an example of an electron beam pattern inspection system. An electron beam 2 from an electron beam source 1 is deflected in the X direction by a deflector 3, and is irradiated onto a target substrate 5 via an object lens 4 while a stage 6 is simultaneously made to move continuously in the Y direction, and a secondary electron 7 from the target substrate 5 is detected by a detector 8, the detected signal is converted from analog to digital by an analog-to-digital (A/D) converter 9, and, as a digital image, is compared by an image processing circuit 10 to a digital image of a place that can be expected to be the same as the original, a place that differs is detected as a pattern defect 11, and the location of the defect is established.

Fig. 2 shows the constitution disclosed in Japanese Patent Laid-open No. H11-160247 as an example of an optical inspection system. A light from a light source 21 is irradiated onto a target substrate 5 via an object lens 22, and a reflected light is detected by an image sensor 23 at that time. By repeatedly detecting the reflected light while a stage 6 moves at a constant speed, an image is detected as a detected image 24, and stored in memory 25. [This detected image 24] is compared against a memory 25-stored image 27, which can be expected to be the same pattern as the detected image 24, and if the patterns are identical, the detected image 24 is determined to be a normal portion, but if the patterns differ, this difference is detected as a pattern defect 11, and the defect location is established.

As an example, Fig. 3 shows a layout of when a target substrate 5 is a wafer 31. Dies 32, which are ultimately cut apart to yield individual products of the same variety, are formed on wafer 31. Stage 6 is moved along a scanning line 33, and an image of the stripe region 34 is detected. When the present detection location A is 35, an image of detection location B 36 in memory 25 is extracted as a stored image 27, and the two images are compared. Thereby, detection location A 35 is compared against a pattern that can be expected to be an identical pattern. Here, memory 25 possesses capacity capable of holding an image that can be expected to be an identical pattern, that is used repeatedly in a ring shape to form an actual circuit.

In case of the both inspection systems, to confirm the results of the inspection, the inspected data was outputted to a review system. Thereafter, the wafer was transferred to and set on a table of the review system to review defects detected by the inspection system. In the review system, the defect to be reviewed was placed in a viewing field of the review system by using the inspected data outputted from the inspection system. Then visually observing the image to judging whether or not it was an actual defect or to infer what could have caused it. In these reviewing method, a vast amounts of image data acquired by the inspection were not effectively used.

SUMMARY OF THE INVENTION

The present invention is constituted such that an image of a defect portion, which is similar to an image of a defect portion specified on the basis of inspection results outputted by an inspection system and the defect portion image data thereof, is retrieved, and the conditions for the occurrence of a specific mode defect, which occurred in the past, can be grasped by displaying the retrieval results so as to enable identification.

A first constitution according to the present invention will be explained. A constitution that uses an electron beam will be shown here, but it is substantially identical to a constitution, which utilizes another charged particle.

Fig. 4 shows the constitution. It is constituted from an electron beam source 1 for generating an electron beam 2; and a deflector 3 for deflecting

electron beam 2; and an object lens 4 for converging electron beam 2 onto a target substrate 5; and a stage 6 for holding, scanning and positioning target substrate 5; and a detector 8 for detecting a secondary electron 7 from target substrate 5; and an A/D converter 9 for converting a detected signal from analog to digital and forming a digital image; and an image processing circuit 110 for comparing the digital image against a digital image of a location that can be expected to be substantially identical, and detecting a location that is different as a pattern defect 11; and defect data storing means 201 for storing defect data 200 comprising the defect location and image data of pattern defect 11; and data outputting means 203 for outputting stored defect data 202 to either a network or a storage medium; and inputting means 205 for inputting a defect data 202 related to a plurality of wafers, which was outputted to data transferring means 204 by data outputting means 203; and defect data storing means 206 for storing inputted defect data; and a defect map 207 for displaying defect location data of the wafer on a display screen and selecting means 208 for selecting specific defect on the defect map 207; and image displaying means 209 for displaying image data of selected defect data in an image format; search command means 210 for issuing a command for retrieving from the defect data group a defect image that is similar to a displayed image; and image retrieving means 211 for retrieving an image having image data that is similar to a displayed image.

Electron beam 2 from electron beam source 1 is irradiated onto target substrate 5 via object lens 4, and generated secondary electron 7 is detected by detector 8. Electron beam 1 is deflected by deflector 3, image data is formed by using stage 6 for scanning target substrate 5, [this image data] is converted from analog to digital by A/D converter 9, and a digital image is formed. Image processing circuit 110 compares this digital image with a digital image which is expected to be substantially identical, and detects a difference between the two images as a pattern defect 11. Defect data 200, comprising the defect location and image data of detected pattern defect 11, is stored in defect data storing means 201, and stored defect data 202 is outputted by data outputting means 203 as necessary to information transferring means 204 of either a network or a storage medium.

Defect data 202 of a plurality of wafers, which is outputted from outputting means 203, is inputted by inputting means 205 and is stored in a storing means 206, and the defect location data of the inputted defect data is displayed in defect map 207. When a specific defect on the defect map is selected by selecting means 208, an image of the selected specific defect is displayed on image displaying means 209. When a command is issued by search command means 210, a defect image similar to the displayed image is retrieved from among the stored defect data stored in the storing means 206 by image retrieving means 211, and the retrieval results are reflected in defect map 207. Retrieval results can be checked as needed by issuing a

command via selecting means 208. The frequency at which similar defects occur can be checked by displaying in the time-series format shown in Fig. 5 a display format of defect map 207. In accordance therewith, the image data acquired at inspection time can be utilized effectively.

These and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a front view showing a simplified constitution of a conventional electron beam-type pattern inspection system;

Fig. 2 is a front view showing a simplified constitution of a conventional optical-type pattern inspection system;

Fig. 3 is a plan view showing a wafer layout;

Fig. 4 is a block diagram showing a simplified constitution of solution means of the present invention;

Fig. 5 is a graph showing occurrence frequency trends of defects;

Fig. 6 is a block diagram showing the overall constitution of a pattern inspection system according to the present invention;

Fig. 7 is a front view showing a simplified constitution of an inspection system according to the present invention; and

Fig. 8 is a front view of a display screen showing an example of a display screen of a results confirmation system according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiments of the present invention will be explained hereinbelow using specific figures. The overall system will be explained first, and then the respective parts of the system will be explained.

(Overall System)

The constitution of the first embodiment is shown in Fig. 6. This first embodiment is constituted from a server 151, which is arranged on a network 150, and which manages and stores various information; and an SEM (scanning electron microscope)-type pattern inspection system, an optical-type pattern inspection system, an extraneous material inspection system, a length-measuring SEM, and other such inspection systems A 152 and inspection systems B 153, which treat a target substrate 5 as an object, and inspect patterns and measure dimensions; a review system 154 for receiving inspection results from inspection system A 152 and inspection system B 153, positioning target substrate 5 at a specified defect location, and visually checking this specified defect; and a defect checking system 155 for receiving and checking either inspection or measurement data at inspection time. The respective parts satisfy their functionality by operating as described hereinbelow.

That is, a target substrate 5 is loaded, and either a pattern inspection or an extraneous material inspection is carried out, or pattern dimensions are measured by inspection system A 152 and inspection system B 153.

Measurement results 160, together with image data 161 of defective parts and measured portions are stored when inspection and measurement are performed, and measurement results 160 and image data 161 are outputted over network 150. These data are stored in server 151 one time.

Information of the measurement results 160 and image data 161 of a plurality of target substrate 5 stored in server 151 is transmitted to defect review system 154, and measurement results 160 are displayed on defect confirmation system 155. Based on the displayed results, image data 161 of a defective portion, which is similar to the image of a specific defect, is retrieved using a method, which will be explained hereinbelow, and the retrieval results are reflected on a display.

A first variation of this embodiment will be explained. That is, instead of executing a search via a defect checking system 155, a search can be executed via either inspection system A 152, or inspection system B 153, or server 151, or review system 154. Or, instead of the checking system 155, a search server 156 which is connected to the network 150 is provided, and a search is executed by the search server 156 and only the results are displayed via a system other than defect checking system 155 or search

server 156. Further, a search can be executed by an arbitrary system without the need to provide search server 156 independently.

(Inspection System)

The constitution of a SEM-type pattern inspection system is shown in Fig. 7. This constitution comprises an electron beam source 1 for generating an electron beam 2; and an electron optical system 64 having an electron gun for accelerating and extracting an electron beam 2 from electron beam source 1 by means of an electrode, and creating a virtual light source in a fixed location by means of an electrostatic or magnetic field superimposed lens, a condenser lens 60 for converging an electron beam 2 from virtual light source 40 in a fixed location, a blanking plate 104, which is set near the convergence location, and which controls the ON/OFF of an electron beam 2 from electron gun, a deflector 105 for deflecting an electron beam 2 in the XY directions, and an object lens 4 for converging an electron beam 2 onto a target substrate 5; and a sample chamber 107 for maintaining a wafer 31, which is target substrate 5, in a vacuum; a stage 6, on which is mounted the wafer 31, and to which is applied a retarding voltage 108 for making it possible to detect an image of an arbitrary location; and detector 8 for detecting a secondary electron 7 from target substrate 5; and A/D converter 9 for converting a detected signal detected by detector 8 from analog to digital and producing a digital image; and memory 109 for storing a digital image; and an image processing circuit 110 for comparing a stored image stored in memory 109

with an A/D converted digital image, and detecting difference between the compared two images as a pattern defect 11; and a pattern defect storage portion 201 for storing defect data 200, such as pattern defect 11 coordinates, projected length, area, critical threshold value DD (the threshold value at which, when the threshold value is lower than this value, a defect is detected), differential image average value, differential image distribution, maximum image difference, defect image texture, reference image texture, image of a defect portion, and a reference image having a pattern that is identical to that of the defect portion; and data outputting means 203 for outputting stored defect data 200 to either a network or a storage medium; and a system controller 100 for controlling the entire system (control lines from system controller 100 are omitted from the figure); and an operating screen 45 for performing various operations; and a keyboard (not shown), mouse (not shown) and knob (not shown) for specifying operations; and a Z sensor 113 for maintaining the focal point position of a detected digital image constant by measuring the height of a wafer 31, and adding and controlling an offset 112 to the current value of object lens 4; and a loader (not shown) for loading and unloading wafers 31 inside a cassette 114 into sample chamber 107; and an orientation flat detector 117 (not shown) for positioning the wafer 31 using the outline shape of a wafer 31 as a reference; and an optical microscope 118 for observing a pattern on the wafer 31; and a standard sample 119, which is provided on stage 6.

The operation of the inspection system will be explained. When an inspection is started by a command from a user, stage 6 moves and the region to-be-inspected of the wafer 31 mounted on the stage 6 is to the scanning start position. A wafer-specific offset measured beforehand is added and set in offset 112, Z sensor 113 is made operative, stage 6 scans in the Y direction along scanning line 33 shown in Fig. 3, deflector 105 scans in the X direction in synchronization with the scan of the stage, the voltage of blanking plate 104 is shut off at effective scanning time, and an electron beam 2 is irradiated onto wafer 31 and scanning is performed. Either a reflected electron or a secondary electron generated from wafer 31 is detected by detector 8, a digital image of stripe region 34 is produced by A/D converter 9, and then stored in memory 109 and inputted in image processing circuit 110 in parallel. Upon termination of the scan of stage 6, Z sensor 54 is made inoperative.

An inspection of all required regions is done by repeating the scan of the stage 6. When the detection is carried out in the location A 35 (Refer to Fig. 3), image processing circuit 110 compares a detected image of the location A 35 with an image of detection location B 36 (Refer to Fig. 3) stored in memory 109, and extracts a discrepancy between both images as a pattern defect 11, and stores the image of detection location A 36 in defect data storage means 201. Defect data 200, such as extracted pattern defect 11 coordinates, projected length, area, critical threshold value DD (the threshold

value at which, when the threshold value is lower than this value, a defect is detected), differential image average value, differential image distribution, maximum image difference, defect image texture, reference image texture, and image data, is stored in defect data storage means 201. And from data outputting means 203 is outputted as needed to data transferring means 204, which is either a network or an MO (magneto-optical disk), CDR (compact disk - recordable), DVD (digital video disk), FD (floppy disk) or other storage medium.

(Results Confirmation System)

Outputted defect data 202 is inputted via inputting means 205 of results confirmation system 155 either via a network or from a storage medium, and defect location data from among the inputted defect data is displayed on defect map 207. When a specific item on the defect map is selected by selecting means 208, image data of the defect data is displayed in image format on image displaying means 209. When a command is issued by search command means 210, a defect image similar to the display image is retrieved by image retrieving means 211 from among the defect data group, and retrieval results are reflected on defect map 207. Retrieval results can be checked as needed by issuing a command via selecting means 208. The frequency at which similar defects occur can be checked by displaying in the time-series format shown in Fig. 5 a display format of defect map 207. In

accordance therewith, the image data acquired at inspection time can be utilized effectively.

An example of a display screen of results confirmation system 155 is shown in Fig. 8. The location on a substrate (wafer) of each detected defect is displayed on map display portion 55, which corresponds to defect map 207 of Fig. 4.

Further, an image of a defect specified from among the defects displayed on the map display portion is displayed on image display portion 56, which corresponds to image displaying means 209 of Fig. 4. Specifying a defect for displaying this image is done by operating a mouse operation command button 140. That is, a current location symbol 59 is displayed on the screen by using the mouse operation command button 140 to select the selection mode 145 from among a selection mode 145 and a zooming mode 146, the current location display 59 is moved with the mouse (not shown in the figure), and the image of a defect that [a user] wishes to see is displayed on image display portion 56 by clicking on the location of the defect to be viewed.

Further, when the zooming mode 146 is selected with the mouse operation command button 140, a display on map display portion 55 of the distribution of defects on a substrate can be either enlarged or reduced.

According to the present invention, an image of a defect portion, which is similar to an image of a defect portion specified on the basis of inspection

results outputted by an inspection system and the defect portion image data thereof, is retrieved, and the conditions for the occurrence of a specific mode defect, which occurred in the past, can be grasped by displaying the retrieval results so as to enable identification. Further, [the present invention] is characterized in that it enables the provision of functions for sounding an alarm in response to a future specific mode-generated defect by setting retrieval conditions in the inspection system.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.